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International Research Trends and Methods for Walkability and Their Enlightenment in China

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Abstract

In recent years, new urbanism design for walkability has been a major focus of city planning. Walkability contributes to the health, well-being, and quality of life of citizens in cities. The link between walkability in cities and the health of citizens' need more indepth research and a comprehensive appraisal of the international research methods for walkability will a good start to build foundation to define research focus and to provide some references for China which is going through a fast urbanization process. This paper discusses the importance of walkability in the new urban development, which has close relationship with public health, urban form and transportation. This paper through literature review, conducts an international comparative study of research methods used for conducting research on walkability. It provides a brief overview of theoretical frameworks that define and measure walkability in different subjects. The method used in this paper includes the following. In order to explore the trend and methodology objectively among related subjects, a database is set up by the software Histcite and CiteSpace, consisting of 813 related papers included in the database of "Web of Science" and 16468 indirect papers referenced by the 813 papers. The citation relationships between these related papers are then analyzed by Histcite and CiteSpace in order to find the connection between different subjects of the papers. The fields of geography, transportation and sociology, and other related research perspectives and contents have been discussed.The result of this review of other countries offers an empirical approach and evidence for a definition of measurable attributes and thresholds for walkable city research in general. It also provides reference with the walkability index and methods for Chinese city planners to meet the China's conditions in future.

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Keywords: Walkability; Histcite and CiteSpace; Research Methods ; Comparative Study ; China

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1. Background

In China, with the acceleration of urbanization, overspread of cities has gained more gravity. As a result, many cities are currently planning a transition phase from diffused to contracted urban structures. In the past, cities had sparse buildings and high transportation dependency. However, the urban sprawl not only consumed a large amount of farmlands and other natural resources, but also reduced the service efficiency of public facilities, which caused many environmental and social problems. In order to curb urban overspreading, governments have defined rigid growth boundary around the city and have strongly advocated intermodal transportation and compact neighborhoods. The Chinese governance city work conference has proposed the concept of "compact city" and "smart growth" to promote urban development in both inside and outside of some cities [1].

This is also the case in some other countries. The United States, which is the earliest suburbanized country, has experienced urban expansion by virtue of developing suburbs. Subsequently, due to its serious damage inflicted on the environment, economy, social development and so on, the American Planning Association then established the "Smart Growth America" union with other public organizations in 2000 and proposed a new way of developing compact, intensive, and efficient cities. At the same time, it joined the Walker Association in the 21st century together with other 19 other countries including the UK, France, Canada, and Australia, to carry out urban development activities in communities, with discussion of the results at annual general meetings [2].

Facilitating simple physical activities, for example, like walking, has great potential to solve an array of issues in different aspects of the society, from economical to environmental and of course to health. It brings an active lifestyle for all citizens. From the perspective of the society, high walkability of a community equates to high residential density and diversity of travel destination, as a result, the utilization rate of public facilities can be increased [3]. In addition, due to the slower pace of walking, people get more opportunities to communicate with other pedestrians to enhance neighbourhood connections [4].Some studies have indicated that a high walkability score of an area can raise housing prices [5].Other researchers believe that walking can effectively reduce obesity and chronic diseases [6].

With the greater dispersion of knowledge through publication and the media, the increased availability of information on different subjects, can make it difficult to read all literatures about the positive effects of walkability. An effective way to solve this problem is to use modern literature analysis software as a supplementary tool to objectively assess the development trend. This paper uses the software Histcite and visualization software platform Citespace to grasp development trend and hotspots related to the research through all related literatures in recent years from the “web of science” database.

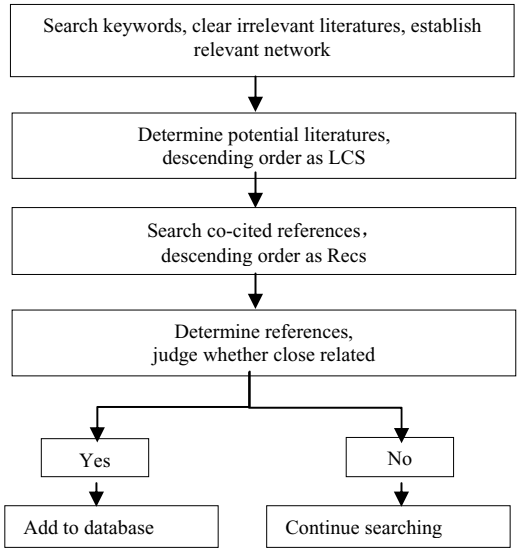

Fig 1. The process of setting database

2. Database and Methods:

This paper draws upon the quotation analysis software on the basis of traditional literature reading. In the database Web of Science, "walkability" is set as the keyword in the search of all literatures from 1994 to 2016. 875 relevant works were retrieved, but not all are relevant to cities.

With the help of the analysis software—Histcite, directly relevant literatures have been determined as potential literatures by two major indicators. One is the frequency of words in the title, and the other is the frequency of citation. After analyzing co-cited references, potential texts are sorted out in descending order based on local citation score (LCS). In the next stage, according to literatures with high local citation score and the references from all relevant literatures, the number of indirect

literatures is 16468. Finally, whether to add these into the literature database or not is determined by the titles of literatures and the co-cited frequency. The basic process of determining literature database is shown in Fig. 1.

Although Histcite can add useful but missing selections easily, it is not good enough in terms of visual effects. To supplement this weakness, CiteSpace is also used to show the result and trend after analyzing. In spite of using these methods, the traditional method of literature reading is still necessary. Reading and organizing hot literatures is still the important work in the process of this study.

From the perspective of content, the database includes two parts. First is the direct literatures which contain literature network in detail. They are the core of literature database. Second is the references which include the reference data of direct literatures. It has more literatures and a longer time span.

In this paper, the literature database contains 813 direct literatures from 2001 to 2016 and 16468 indirect literatures which can be traced back to 1895. The number of authors total to 2096 people, including 1666 keywords. From the perspective of the affiliation distribution of authors, the top five countries are United States, Canada, Australia, China, and Belgium.

3. Literature Content Analysis

3.1. Research areas and hotspot

1）Multitudinous research areas:

According to the analysis from the Web of Science, the literature research area includes 72 different areas. The top five areas are: public environmental occupational health (408 records), general internal medicine (115 records), environmental sciences ecology (101 records), nutrition dietetics (98 records), and endocrinology metabolism (61 records). Published items and citations every year show an upward trend in general (see Fig. 2).

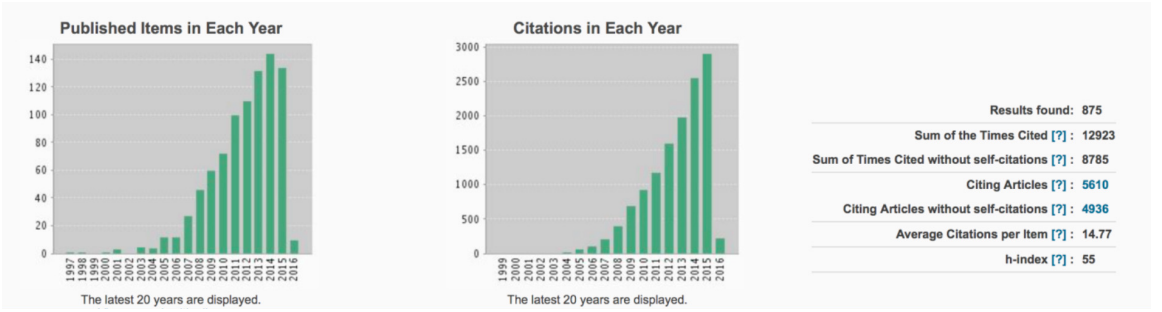

Fig.2. Published items and citations trend (citing by Web of Science)

According to the analysis of CiteSpace software and the database built previously, research areas are identified by cluster from noun phrases and/or burst term in title, keywords, and abstract. After processing, the kinds of cluster which analyzed by noun phrases in title are 67, and the kinds of burst term are 15. The number of citation references reached a peak in 2003 and in 2005. After analyzing from published items and citations trends since 1990, the top five clusters based on noun phrases were found to be neighbourhood, economic value, environmental audit instrument, future demand and school. The top five clusters based on burst terms were expenditure, Melbourne, social-environmental determinant, possibilities and guard.

According to timeline analyzed by CiteSpace, walkability research began to form the first hotspot in 1997. The major content of the hot papers is about environmental protection. The research area has been expanded to embrace many areas. This can be easily noticed because the Total Global Cited References Score (TGCS) soared from less than 40 before 2002 to more than 1,000 since 2003. Papers written by Saelens B E, Sallis J F, De Bourdeaudhuij [3], [7, 8, 9, 12] and other authors were hot zone pioneers in this field in 2003. Their studies mainly focused on the impacts of walking around the environment on elderly people and women, as well as its influence on the physical activities. In the following year, many hot papers written by Frank L D [15, 17, 19], Owen N[31] , Kerr J [14] and so forth have been published. The research area has been expanded to neighborhood, environment, and health. After

2011, due to accumulation process of citation literatures, consequently rings of hot literatures have no longer as big size as before.

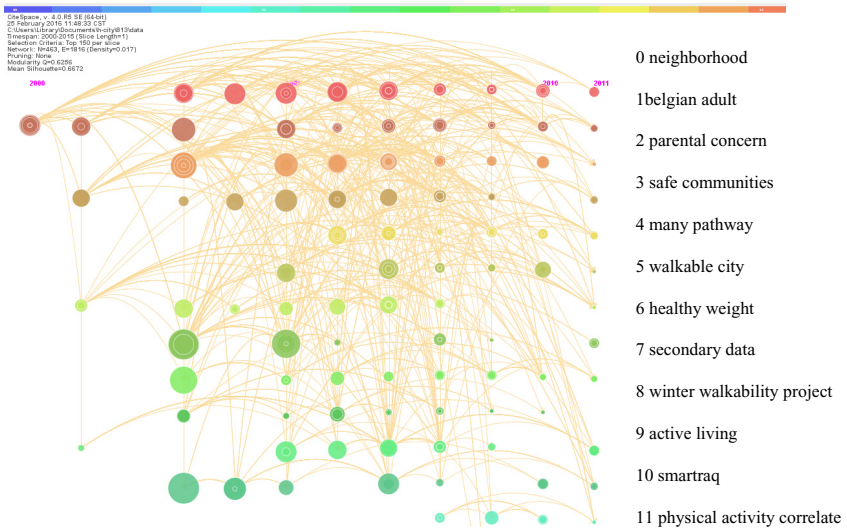

Fig. 3. Citation timeline analysis of hot burst after 2000 year(cited by CiteSpace)

Fig. 3 shows the frequency of literature citations throughout history. The horizontal axis represents the year, while the vertical axis is the result of computer automatic clustering according to different settings. The lines between every ring indicates the connecting number between two articles. The color of the rings represents the hotness of burst, and the size of the ring represents the times of being cited. The site of each ring center stands for the publishing time in the horizontal position.

2) Research hot words:

The number of keywords in directly quotable from such texts is 1666. After being selection process by Histcite, we can found that the top five keywords were included neighborhood, physical, environment, activity, and adults. Table 1 below lists the cited literature titles that appear in the top ten frequency keywords. TLCS is short for Total Local Citation Score

Table1. Top 10 most frequently used words in the title of the local cited literature.

Rank	1	2	3	4	5	6	7	8	9	10
Keyword	environment	neighborhood	physical	activity	adults	built	urban	perceived	older	health
TLCS	287	229	219	204	113	113	69	66	65	61

Burst term is another index to indicate hotspots. It is selected by CiteSpace on the basis of three kinds of algorithms to predict the frontier, development trend, and potential problems. During 30 years, the top five keywords are included bikeability, adult, community, environment instrument, and socio-environmental determinant.

3.2. Non-Mainstream literature analysis

Global Cited Score (GCS) selected by Histcite demonstrates related areas of research around the world. It contains a lot of literatures substantially cited by other disciplines. Although they are not concerned with walkability, they include wider research fields in a longer period, and such coverage can help researchers to broaden horizons and widen thinking. As can be seen in table 2, the non-mainstream areas related to walking include computer-science, prevention policy, pollution and so forth.

Table 2. Top 10 references of GCS and its related properties

Rank (Year)	Author	Title	Keywords	GCS
1 (2003)	Saelens BE et al.	Neighborhood-based differences in physical activity : An environment scale evaluation	computer-science; public-health; activity monitor; interventions; obesity; inc.; transportation; accelerometer; framework; policy	622
2 (2005)	Frank LE et al.	Linking objectively measured physical activity with objectively measured urban form-Findings from SMARTRAQ	computer-science; public-health; community design; activity monitor; land-use; adults; inc.; transportation; participation; accelerometer	433
3 (2008)	Saelens BE, Handy SL	Built environment correlates of walking: A review	walking; built environment; physical activity; urban design	417
4 (2006)	Frank LD et al.	Many pathways from land use to health - Associations between neighborhood walkability and active transportation, body mass index, and air quality	physical-activity questionnaire; built environment; public-health; urban form; travel behavior; communities; pollution; obesity; design; overweight	285
5 (2007)	Frank LD et al.	Stepping towards causation: Do built environments or neighborhood and travel preferences explain physical activity, driving, and obesity?	built environment; preference; obesity; travel; physical activity; USA; neighborhood	212
6 (2007)	Frank LD et al.	Active commuting to school: Associations with environment and parental concerns	physical activity; children; adolescents; walking; barriers	203
7 (2003)	De Bourdeaudhuij et al.	Environmental correlates of physical activity in a sample of Belgian adults	environment; physical activity; walkability; community design; prevention research	200
8 (2007)	Owen N et al.	Neighborhood walkability and the walking behavior of Australian adults	physical-activity questionnaire; urban form; land-use; environment; health; travel; transportation; participation; associations; prevention	186
9 (2006)	Cerin E et al.	Neighborhood environment walkability scale: Validity and development of a short form	multilevel confirmatory factor analysis; walking for transport; walking for recreation; physical activity; built environment	178
10 (2009)	Sallis JF et al.	Neighborhood built environment and income: Examining multiple health outcomes	Obesity; Physical activity; Built environment; Health disparities; USA; Quality of life (QoL); Neighborhood; Walkability	177

4. Research Method Analysis

For finding popular research method, the first step is to review influential literatures. After reviewing research methods used by highly influential articles, the common ways of doing research can be easily found. The hot literature database which is established by Histcite can be determined by Local Cite Score (LCS), as well as the frequency of being cited in the direct literature database. In addition, citation relationship can be described. As Fig. 4 shown, the software chose the top 50 direct literatures from the database, and use LCS as the indicator to show their references among each other (see Fig.4). In this citation chronological chart, there are 50 nodes and 194 lines in total. The number in each circle represents the document number in the database. The connecting line between the nodes shows the reference time between each other. It is easy to find that No. 9, 10, and 12 are the earliest influential papers in the field, and

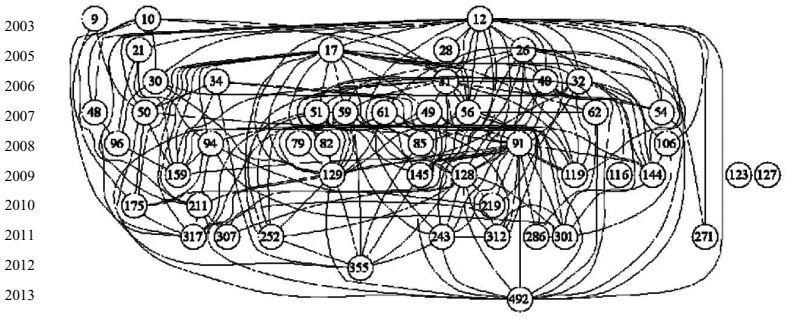

Fig. 4 Top 50 papers of LCS and their citation relationships (cited from HistCite)

No. 492 contains the latest relative result. No. 123 which described the food environment and walkability predict obesity [10] and No. 127 which provided a brief history of measuring physical activity environment [11] may not be closely related to this study although they are often quoted.

The second step is to extract research methods from high score, and then carry out data analyses. The main research methods include individual surveys, questionnaires, accelerometers and geographic information system etc.

1) Subjective Perception

Self-reporting and questionnaires are the most common ways to assess subjective perception. The key procedure is to choose and define the target group.

The objective of the research determines the selection process. In comparison with different neighborhoods, places with high/low density and high/low walkability can be included [12]. When comparing the individual preferences, personal attributes as a variable should be considered, such as age, gender, annual income and so on. As for the health study, the BMI score needs to be provided [13,14]. Other studies focusing on the elderly or youth require different age groups need to be set [15].

Some questionnaires are widely used in related research. The Neighborhood Environment Walkability Scale (NEWS) is one of several recently developed questionnaires designed to measure residents' perceptions of the environmental attributes of their local area [16]. Other surveys and study systems, such as Strategies for Metropolitan Atlanta's Regional Transportation and Air Quality (SMARTRAQ) survey, Neighborhood Quality of Life Study (NQLS), Physical Activity in Localities and Community Environments (PLACE), International Physical Activity Questionnaire (IPAQ) are also popular.

In generally, residents could be mailed or telephoned first to make sure that they consent to participate and to provide reliable information. Participants of the research need to be the long-time residents in order to guarantee this, participants may be selected according to registered address or telephone number. The age, gender, highest level of education attained, household annual income, social class, BMI, and purpose of walking can be evaluated as eligibility criteria [17].

2) Objective Assessment.

a. Accelerometer. Participants can wear it during daily walks [18]. It estimates adults' physical activity, especially of moderate intensity, such as walking [19]. However, due to its high cost, this method is restricted in the extent of its scope.

b. Mathematical Model. These kinds of methods are usually used in other subjects, such as transportation, geography and economy. Cervero and Kockelman proposed a useful construct-Three Ds (density, diversity and design) in transportation to quantify environmental measurements [20]. Then other research added another variable-R (route) [21]. Discrete choice model has proposed for social interactions and neibourhood effect into spatial analyses of transportation area recently [22]. Other geographic models, such as gravity model [23] and radiation mode [24] also contribute to walking behavior.

c. Spatial analysis and GIS. With the aid of Geo-Informatics System, spatial properties can be evaluated visibly. The main elements derived by GIS are connectivity and proximity. In addition, there are also two important land variables: residential density and land mixing degree evaluation. Connectivity is evaluated according to street networks among residences, shops, and worksites to identify whether there is anything blocking or not (highway, walls and physical barriers, etc.) and whether there are alternative routes [25, 26]. Proximity is related to use of mixed-land uses that shorten distances between residences and destinations [14]. Accessibility, another important factor, is also usually considered and is closely related to connectivity and proximity. In response, Australian researchers proposed 3 measures for this: Pedsheds, link node ratio, and pedestrian route directness [27]. Walkability index is also a widely used evaluation indicator, including four components: land-use mix, residential density, commercial density (also called retail floor area ratio), and street connectivity. These elements are synergistic and can be assessed objectively under the help of geographic information systems (GIS) software.

d. Composite assessment tools. These are integrated into a composite value of overall walkability to measure the external environmental factors. These assessment tools added more factors than physical environmental elements; among these factors are comfort, safety issues, crime prevention and so forth. Walking Suitability Assessment Form (WSAF) in America use 15 values to evaluate the walkability of road segments [28]. Systematic Pedestrian and Cycling Environmental Scan (SPACES) and Analytic Audit Tool (AAT) are also used to measure which physical environment factors have the greatest impact on physical activity, such as walking or cycling [29,30].

Nevertheless, there were no significant associations between environmental factors and walking for recreation in Australian study. Walkability was related to higher frequency of transport walking, irrespective of neighborhood self-selection [31]. The research could be divided according to different walking purpose.

5. Discussion

In conclusion, in terms of research content, most of studies make comparison through evaluation and observation of different kinds of neighborhoods and different levels of socioeconomic status at the same time. In terms of research methods, the conventional way is to carry out self-reporting or questionnaire investigation to collect data, and then to analyze via statistical methods. If combined with data from accelerometers worn by participants, overall data would be more objective and comprehensive. In the meantime, with the development of 3D technology, GIS combined with mathematical calculators enables deeper data mining and more convenient and comprehensive visual displays. Both research content and methods are developing thanks to new tools and technologies.

In the future, the first key point is to identify how to increase walking and public transplantation, and how to combine them effectively. Walking has been a major form of transportation activity in most of cities for a long time. Although it used to be more of the case in Chinese cities than in developed countries, the urban form has become the same due to current motorized developments now. In recent years, faced with increasing problems resulting from this development such as traffic jams, air pollution, and health risks [31]. We have to review the current development mode. Whether it should be changed and, if so, how can any adaptations be designed and implemented? Given China's current population and limited land use, a combination of walking and public transport should be advocated instead of more private cars. This research is headed towards this direction.

Furthermore, a longitudinal study is a more suitable to the context of China because the value will be more helpful on Chinese condition. The land use structure in China is undergoing rapid changes. The practice of changing residence and worksite is quite common. Due to this beneficial factor, longitudinal studies could be easy to carry out. Future researches could focus on the same group of citizens who have changed living and working location and compare their walking habits to achieve new results. This method will not only give a frontier experience to the whole research area, but will also provide a rigorous example of thorough assessment on the connection between walking behavior and the environment.

Finally, the technology of Big Data leads to a new thinking paradigms about scientific research, which can be useful in walkability research. As it brings more and more impact on many study fields, including commercial, economic, and spatial behavior, its great value can be considered as similar to computer revolution in the 20th century's [32]. The United States has proposed a strategy at the national level and launched the "Big Data Research and Development Initiative" project. In China, the platform of science and technology has been established in many provinces, including 28 kinds of science and technology information database [33]. As a result, traditional analysis theories, which are complex and difficult to use in solving problems, can be updated by Big Data. It has been widely used in geography and transportation research.

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